



# **Swift Creek Reservoir Water Quality Data Report 2015**



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Department of Environmental Engineering  
Water Quality Section  
&  
Department of Utilities  
Addison-Evans Water Production/Laboratory Facility**

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## **Executive Summary**

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory Staff for the period of January through December 2015 and represents the twenty third consecutive year of monitoring of the Swift Creek Reservoir. During 2015, pool elevations measured at the dam ranged from 174.6 to 178.0 feet above mean sea level, corresponding to an approximate reservoir volume between 3.5 to 5.0 billion gallons. Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone. Rainfall over the reservoir and its watershed totaled 50.81 inches, 8.01 inches above the long-term average. During 2015, approximately 1,200 pounds of copper sulfate were applied in July to treat algae growth in the reservoir. The applications of copper sulfate assist to improve source water quality for the optimization of the water treatment process.

A similar concentration of chlorophyll *a* was observed in 2015 as compared to the previous year indicating a consistent presence of algae in the reservoir. The growing season 90<sup>th</sup> percentile concentration for the mainbody reservoir stations (Stations 4, 5, 6 and 8) was 37.5 µg/L; a decrease from the 44.8 µg/L value observed in 2014. Four stations (Stations 2, 6, 7 and 8) exceeded the 35 µg/L criteria value for the growing season 90<sup>th</sup> percentile indicating higher than acceptable levels of algal growth.

Throughout the reservoir, total phosphorus concentrations remained consistent with those observed in 2014. The growing season median total phosphorus concentration for the surface water of the main body stations (Stations 4, 5, 6 and 8) was 0.028 mg/L as P; below the Virginia Department of Environmental Quality (VADEQ) nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for the surface water at all eight sites in Swift Creek Reservoir was 0.033 mg/L as P, below the county goal of 0.05 mg/L as P.

During 2015, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper areas beginning in early May and lasting through mid-September. During the stratification period, dissolved oxygen concentrations within the epilimnion were above the VADEQ minimum criterion of 4.0 mg/L for all stations.

Median growing season Secchi disk readings ranged from 2.5 to 3.5 feet, similar to values noted in prior reports. The growing season median throughout the reservoir for turbidity (4.2 NTUs) during 2015 remained consistent with the previous year indicating overall acceptable water clarity. The long-term consistency of both the Secchi disk depth and turbidity parameter measurements suggests minimal long-term variability in water clarity. The 2015 growing season

median total suspended solids concentration for all stations (3.4 mg/L) was similar to the concentration observed in 2014 (4.0 mg/L). Total nitrogen levels remained consistent throughout the reservoir. The growing season total nitrogen concentrations were similar to those observed in 2014 with site medians ranging from 0.57 to 0.64 mg/L as N and indicated a nominal decrease in nitrogen enrichment. *E. coli* median densities remained acceptable with one individual value greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season.

Water temperature in Swift Creek Reservoir varied normally according to season during 2015. Surface pH values ranged from 6.1 to 9.3 units with an annual in-lake median of 7.2 units. Conductivity measurements within the reservoir ranged from 46 to 274  $\mu\text{S}/\text{cm}$  with an annual median of 83  $\mu\text{S}/\text{cm}$ . Lead concentrations ranged from below the reporting limit ( $<0.0025$  mg/L) to 0.0030 mg/L with one measurable concentration recorded during 2015. All zinc concentrations were below the laboratory's detection limit (0.05 mg/L), a decrease from the four measurable concentrations noted during 2014.

A total of 43 individual genera of algae representing six phyla were documented during 2015. Analysis of the general types of algae by phyla in the reservoir indicated that the community structure continued to be comprised largely of green algae (Chlorophyta) and golden algae/diatoms (Chrysophyta). The frequency of occurrence for the taste and odor producing blue-green algae quadrupled as compared to 2014 and approximately double the quantity observed in 2013. There were no widespread taste and odor related problems resulting from algae reported in 2015.

The more vegetative structures of the *Hydrilla* plant had been minimal in 2012 and 2013; in 2014, the *Hydrilla* biomass reestablished itself in the reservoir. In April of 2015, an additional 1,000 triploid grass carp were stocked into the reservoir with the goal of maintaining the *Hydrilla* biomass at a manageable level.

## **Introduction**

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory staff between January and December 2015 and is the twenty third consecutive year of monitoring of the Swift Creek Reservoir. The Swift Creek Reservoir is a public water supply for Chesterfield County located approximately 20 miles southwest of Richmond, Virginia. The reservoir is a 1,700-acre impoundment containing approximately 5.0 billion gallons of water at full pool elevation (177.0 feet above mean sea level). The portion of the Swift Creek Reservoir watershed located within the northwest corner of the county encompasses approximately 51.6 square miles. Although residential development is common in the reservoir's drainage area (36.1% for all residential categories), the most recent land use data (Table 1) indicates the majority (51.7%) of the watershed is comprised of vacant (undeveloped) properties.

*Table 1. Land Use Characteristics of the Swift Creek Reservoir Watershed within Chesterfield County. Data obtained from the Chesterfield County Planning Department Development Potential Database 2015. Categories are arranged in descending order of prevalence.*

<b>Land Use Category</b>	<b>Area (acres)</b>	<b>Area (miles<sup>2</sup>)</b>	<b>Percent of Watershed</b>
Vacant (Undeveloped)	17,104	26.7	51.7
Single Family	6,145	9.6	18.5
Residential Single Family (Subdivisions)	5,431	8.5	16.4
Water	1,607	2.5	4.9
Public/Semi-Public	1,602	2.5	4.8
Commercial	388	0.6	1.2
Utility	251	0.4	0.8
Residential - Multi-Family	151	0.2	0.5
Residential - Townhouse	146	0.2	0.4
Office	119	0.2	0.4
Residential - Condominium	98	0.2	0.3
Industrial	38	0.0	0.1
<b>Total</b>	<b>33,080</b>	<b>51.6</b>	<b>100.0</b>

During 2015, pool elevations measured at the dam ranged from 174.6 to 178.0 feet above mean sea level, corresponding to an approximate reservoir volume between 3.5 to 5.0 billion gallons. Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone Stations 5 and 8 (Figure 1). At these deeper water sites, discrete epilimnion, metalimnion, and hypolimnion samples were taken for nutrient analysis. All other stations in the reservoir (sites 1, 2, 3, 4, 6 and 7) were sampled at the surface only.

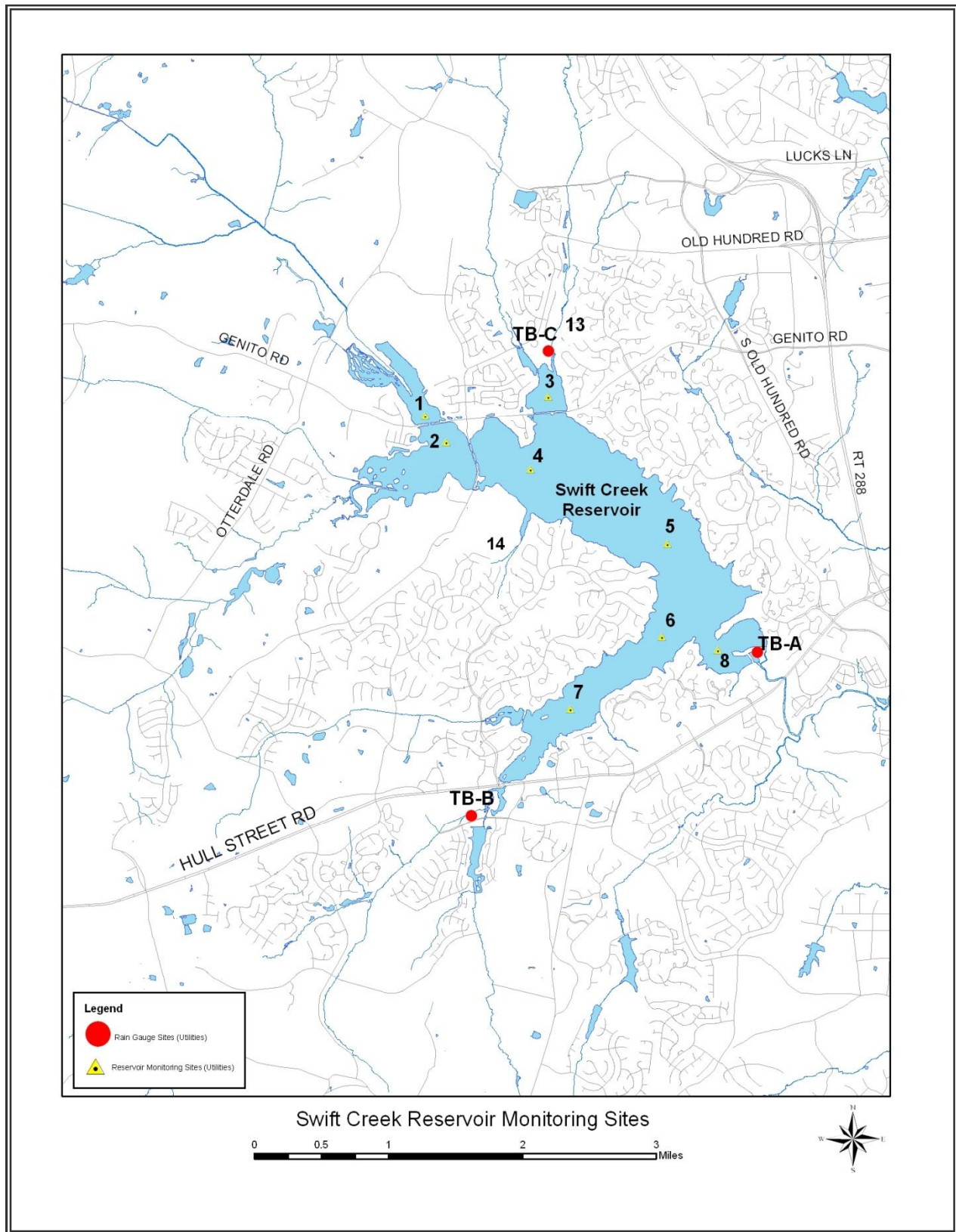


Figure 1. Map of Swift Creek Reservoir monitoring stations.



Water quality parameters (Table 2) were chosen to provide information on basic water quality and the ecological health of the reservoir. Details concerning specific analytical procedures are listed in Table 3.

*Table 2. Sampling Regime for Swift Creek Reservoir 2015.*

PARAMETER	RESERVOIR STATIONS 1,2,3,4,7	RESERVOIR STATIONS 5,6,8
DEPTH	X1	X1A
SECCHI DISC	X	X
WATER TEMPERATURE	X1	X1A
DISSOLVED OXYGEN (Given as mg/L & % saturation)	X1	X1A
CONDUCTIVITY	X1	X1A
pH	X1	X1A
OXIDATION REDUCTION POTENTIAL	X1	X1A
TOTAL PHOSPHORUS	X2	X3
ORTHO PHOSPHATE PHOSPHORUS	X2	X3
TOTAL KJELDAHL NITROGEN	X2	X3
OXIDIZED NITROGEN	X2	X3
AMMONIA NITROGEN	X2	X3
TOTAL ORGANIC CARBON	X2, 1/QTR	X2, 1/QTR
LEAD	X2, 1/QTR	X2, 1/QTR
ZINC	X2, 1/QTR	X2, 1/QTR
SUSPENDED SOLIDS/TURBIDITY	X2	X2
CHLOROPHYLL <i>a</i>	X4	X4
PHEOPHYTIN <i>a</i>	X4	X4
ALGAE COUNTS	X4	X4
<i>ESCHERICHIA Coli</i> ( <i>E. coli</i> )	X2	X2

X1 – ONE METER INTERVALS

X1A – ONE FOOT INTERVALS

X2 – SURFACE SAMPLING ONLY

X3 – DISCRETE SAMPLES OF EPILIMNION, METALIMNION AND HYPOLIMNION WHEN STRATIFICATION EXISTS **OR** SURFACE, MID-DEPTH AND NEAR BOTTOM WHEN NO STRATIFICATION IS PRESENT

X4 – A COMPOSITE OF BENEATH SURFACE, 1/2/ SECCHI DEPTH, SECCHI DEPTH AND 1-1/2 SECCHI DEPTH SAMPLES

*Table 3. Parameters and Analytical Methods 2015.* When Reporting Limit based upon detection is not an applicable measurement for a parameter, it has been replaced by an estimation of accuracy (e.g. pH measurement has an estimated accuracy of 0.2 units) as indicated by (\*).

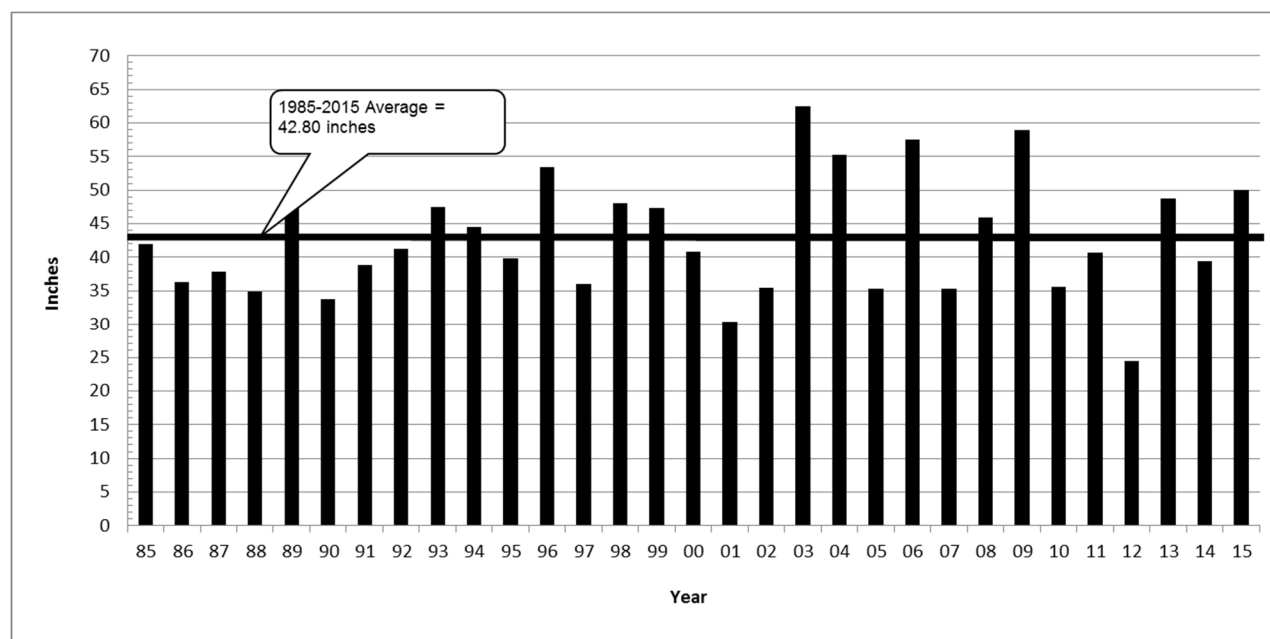
Parameter	Analytical Method	Detection Limit
Depth	Probe: Hydrolab MiniSonde	± 0.08 m*
Dissolved Oxygen	Probe: Hydrolab MiniSonde	± 0.2 mg/L*
Oxidation Reduction Potential	Probe: Hydrolab MiniSonde	± 20mV*
Water Temperature	Probe: Hydrolab MiniSonde	± 0.1 °C*
Conductivity	Probe: Hydrolab MiniSonde	± 0.1 µmhos/cm*
pH	Probe: Hydrolab MiniSonde	± 0.2 units
Secchi Depth	20 cm Standard Secchi Disk	± 0.1 ft*
Total Phosphorus	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Orthophosphate	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Total Kjeldahl Nitrogen	Skalar:EPA Approved, Autom.	0.05 mg/L as N
Oxidized Nitrogen	Skalar:EPA Approved, Autom.	0.01 mg/L as N
Ammonia-N	Hach, Method 10205	0.015 mg/L as N
Total Organic Carbon	Standard Methods, 5310C	0.5 mg/L
Lead	EPA 200.9, Platform Furnace	2.5 µg/L
Zinc	EPA 289.1, Flame	50 µg/L
Total Suspended Solids	Standard Methods, 2540D	1.0 mg/L
Chlorophyll <i>a</i>	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Pheophytin <i>a</i>	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Algae Counts	Standard Methods, 10200F	1 cell/mL
<i>ESCHERICHIA Coli</i> ( <i>E. coli</i> ) Density	Standard Methods, 9222B (Quanti-Tray)	1.0 MPN/100mL

**NOTE:** Standard Methods for the Examination of Water and Wastewater, 22th Edition.



Rainfall was measured at three automated tipping bucket rain gages within the watershed. The average rainfall over the watershed totaled 50.81 inches during 2015 (Figure 2). Rainfall was 8.01 inches above the long-term average observed over the last 30 years (42.80 inches).

*Figure 2. Total Annual Estimated Rainfall Recorded for Swift Creek Reservoir Watershed from 1985-2015 (Source data: Department of Utilities).*



### **Quality Assurance and Quality Control**

All analytical methods used were approved by the United States Environmental Protection Agency (EPA), in accordance with Standard Methods for the Examination of Water and Wastewater (Standard Methods) with the exception of the free ammonia analysis, which was conducted following the Hach Chemical Company's test kit procedure. Manufacturers' recommended preventive maintenance procedures were followed for all instruments. For each parameter analyzed, Method Detection Limits (MDLs) were calculated following the EPA procedure as detailed in the Code of Federal Regulations (CFR), Volume 46, Part 136 Appendix B (EPA, 1984). Stock and standard solutions were prepared from American Chemical Society reagent grade materials for preparation of calibration standards. Correlation coefficients were evaluated for each calibration curve and had to be greater than or equal to 0.995 to be used for analysis. To ensure calibration validity throughout an analysis, Continuing Calibration Verifications (CCV) standards were tested after every 10 samples analyzed. Similarly, Continuing Calibration Blanks (CCB) were evaluated after every 10 samples to detect any

baseline drift errors. With each analysis, field blanks and digestion/analytical blanks were evaluated to ensure detection of contamination during sampling or sample preparation. Independent source Standard Reference Materials (SRM) were purchased and used to verify the accuracy of each analysis calibration. When any SRM was not within ten percent (per EPA guidelines) of the true value, or CCB showed baseline drift, corrective actions were implemented and samples reanalyzed. An annual Environmental Resource Associates (ERA) performance evaluation of blind nutrient samples in a split sampling study was conducted and reported concentrations for orthophosphate and total phosphorus, ammonia, oxidized nitrogen, and total Kjeldahl nitrogen were within the limits of the ERA's acceptable analytical values. The nutrient concentrations of the blind samples are of a higher concentration than normally found in our survey program samples. However, as of yet we are not aware of any SRM manufacturer who provides lower concentration blind samples.

## **Results and Discussion**

Eight stations in the reservoir were sampled monthly during 2015. Stations 5 and 8 were sampled twice per month throughout the year to obtain additional data for the deep-water areas. Sampling at all stations included surface grab samples and water column profiles of physical parameters. Supplemental bottom water quality samples were obtained at the mainbody Stations 5 and 8. Specific reports concerning reservoir data are available upon request from the Departments of Environmental Engineering or Utilities.

The county's water quality goal for the annual median concentration of total phosphorus in surface waters is 0.05 mg/L as P or less and was originally based on a Nutrient Controls Standards Workshop held in 1987 by the Virginia Department of Environmental Quality (VADEQ). In June 2006, VADEQ adopted freshwater nutrient standards for 116 lakes and reservoirs in Virginia, including the Swift Creek Reservoir. The EPA approved regulations in July of 2007 and the amended water quality standards [9 VAC 25 - 260] became effective August 14, 2007. These regulations set growing season (April through October) chlorophyll *a* and total phosphorus criteria for Swift Creek Reservoir at 35 µg/L (0.035 mg/L) and 40 µg/L (0.040 mg/L as P) respectively. These growing season measurements are intended not to be exceeded for two consecutive years as measured by the State in their Lake Monitoring Program. Specifically, VADEQ considers the reservoir nutrient enriched if the 90<sup>th</sup> percentile of the chlorophyll *a* data in surface waters of the main body of the reservoir (Stations 4, 5, 6, and 8) during the growing season exceeds the criteria for two consecutive years. However, algaecides use can make the chlorophyll *a* measurements unreliable. If algaecides are used, then both chlorophyll *a* and total phosphorus criteria are applicable. In the Swift Creek Reservoir, the

algaecide copper sulfate is used occasionally to spot treat algal blooms. The algaecide use is variable over the reservoir between months and between years. Because of the algaecide treatments, analysis of the reservoir data has always included both the total phosphorus and chlorophyll *a* criteria. Additionally, VADEQ would consider the reservoir nutrient enriched if the growing season median concentration of total phosphorus in surface waters of the main body of the reservoir exceeded the criterion for two consecutive years.

During 2015, approximately 1,200 pounds of copper sulfate were applied in July to treat algae growth in the reservoir. The 1,200 pounds were applied on July 13<sup>th</sup> throughout the reservoir covering areas in the southern branch, mainbody, fore and intake bays. All applications of copper sulfate were performed to improve source water quality for the optimization of the water treatment process within the plant. Algal blooms are known causes of taste and odor issues in drinking water and can clog filters decreasing available potable water production and supply.

### **Chlorophyll *a***

VADEQ has identified chlorophyll *a* as the most important parameter that can be measured to determine the nutrient enrichment status of a reservoir. Chlorophyll *a*, a green photosynthetic pigment found in algae, is an indirect measure of biological response to nutrient loadings. VADEQ considers the threshold value for nutrient enrichment in Swift Creek Reservoir to be the 90<sup>th</sup> percentile concentration that exceeds 35 µg/L, measured between April and October (*i.e.* the growing season) within the main body for two consecutive years. Seventy chlorophyll *a* samples from the eight sites were collected and analyzed during the growing season.

A similar concentration of chlorophyll *a* was observed in 2015 as compared to the previous year indicating a consistent presence of algae in the reservoir. The growing season 90<sup>th</sup> percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 37.5 µg/L (Table 4), a decrease from the 44.8 µg/L observed in 2014. In 2015, all eight of the stations combined had a 90<sup>th</sup> percentile concentration during the growing season of 41.8 µg/L, nearly identical to the 43.6 µg/L observed in 2014. The greatest individual measurement observed (99.7 µg/L) occurred at the shallow water Station 2 on June 1, 2015. The highest growing season 90<sup>th</sup> percentile concentration (67.3 µg/L) was also observed at Station 2. Four stations (Stations 2, 6, 7 and 8) exceeded the 35 µg/L criteria value for the growing season 90<sup>th</sup> percentile indicating higher than acceptable levels of algal growth.

*Table 4. Growing Season Chlorophyll a Concentrations (Surface) 2015.*

<b>Station</b>	<b>Growing Season 90th Percentile Chlorophyll <i>a</i> (µg/L)</b>
1	32.3
2	67.3
3	18.0
4	31.2
5	32.2
6	39.5
7	61.3
8	37.2
<b>Mainbody Stations (4, 5, 6, 8)</b>	<b>37.5</b>
<b>Shallow Stations (1, 2, 3, 7)</b>	<b>42.7</b>
<b>All Stations</b>	<b>41.8</b>

### **Total Phosphorus**

Total phosphorus is measured as an indicator of nutrient enrichment. To maintain water quality, the county has an established goal of not exceeding an annual median in-lake phosphorus concentration of 0.05 mg/L as P. The VADEQ has adopted a freshwater nutrient criterion of 40 µg/L (0.040 mg/L as P) for the surface waters of the reservoir's main body for the growing season. Seventy total phosphorus samples from the eight sites were collected and analyzed during the growing season. The growing season (April – October) median total phosphorus concentrations for each reservoir station are provided in Table 5.

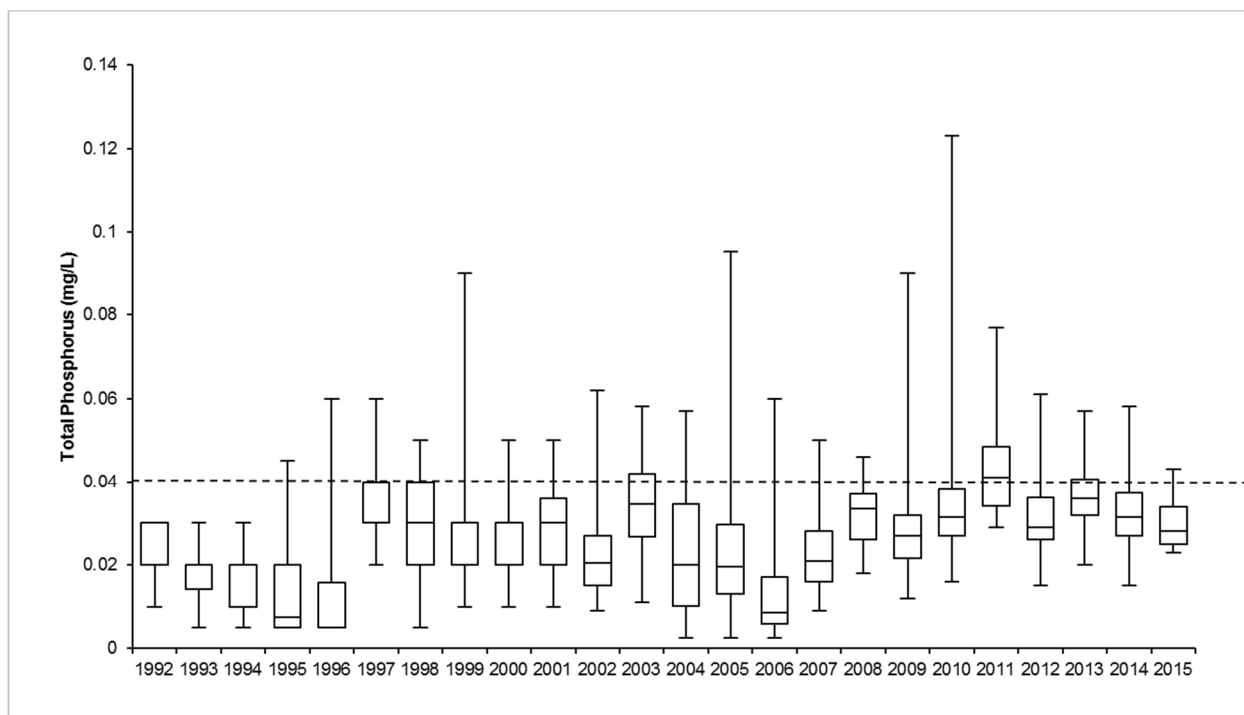
*Table 5. Growing Season Median Total Phosphorus Concentrations (Surface) for 2015.*

<b>Station</b>	<b>Growing Season Median Total Phosphorus (mg/L as P)</b>
1	0.047
2	0.047
3	0.031
4	0.028
5	0.029
6	0.032
7	0.033
8	0.028
<b>Mainbody Stations (4, 5, 6, 8)</b>	<b>0.028</b>
<b>Shallow Stations (1, 2, 3, 7)</b>	<b>0.041</b>
<b>All Stations</b>	<b>0.033</b>

In 2015, the growing season median total phosphorus concentration in the reservoir for all sites

combined was 0.033 mg/L as P, an observation below the county goal of 0.05 mg/L as P. This observation was consistent with the total phosphorus concentration observed in 2014 (0.033 mg/L as P). The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.028 mg/L as P, a decrease from the 0.032 mg/L as P concentration noted in 2014. The growing season median value observed in the mainbody represented a value below the VADEQ freshwater nutrient criterion of 0.04 mg/L as P (Figure 3). Except for Stations 1 and 2, all other individual station's growing season medians were below the 0.04 mg/L as P threshold. At Stations 1 and 2 the growing season medians were greater than 0.04 mg/L as P, indicating nutrient enrichment (Table 5). It should be noted that the state phosphorus criterion is only applicable for the lacustrine zone (Stations 4, 5, 6 and 8) and is not intended as a regulatory value for the shallow, backwater areas of the reservoir. During 2015, for all sites monitored in the reservoir, 34 individual measurements (29.8%) were at or exceeded 0.04 mg/L as P, a decrease from the 2014 observations (n=46; 39.0%). The annual median phosphorus concentration for all eight sites was 0.033 mg/L as P. The total phosphorus levels present in Swift Creek Reservoir indicate that in 2015 this water body exhibited a consistent level of nutrient enrichment.

*Figure 3. Box plot demonstrating the growing season median total phosphorus concentrations and ranges of observations for the surface waters of main body sites within Swift Creek Reservoir 1992 - 2015 Dashed line denotes VADEQ maximum threshold of 0.04 mg/L as P for acceptable water quality.*



Higher concentrations of total phosphorus in anoxic (oxygen depleted) bottom waters as compared with surface water concentrations indicate active phosphorus release from sediments. The release of phosphorus from the sediments results in additional nutrient loading to the reservoir, as this phosphorus is then mixed with the upper water layers during de-stratification. At Stations 5 and 8 during 2015, there were 24 instances where the concentrations of total phosphorus in the benthic sample were greater than the values obtained at the surface; a slight increase from the 21 observed in 2014. Of these 24 instances, eight were considered substantial (*i.e.*  $\geq 50\%$  difference) an increase from the zero observed substantial differences in 2014. The bottom phosphorus concentrations at Stations 5 and 8 ranged from 0.023 to 0.106 mg/L as P. This represented a median bottom concentration of 0.033 mg/L as P; the same as the median surface concentration (0.033 mg/L as P). Additionally, the 2015 bottom concentration was similar to the 2014 bottom concentration of 0.034 mg/L. All other differences noted were minor ( $\leq 50\%$  difference). While total phosphorus contributions from the sediment were not significant this year, in previous years the higher concentrations in the anoxic hypolimnion have contributed to loading within the reservoir.

## **Dissolved Oxygen**

Adequately oxygenated water is critical for a healthy aquatic environment and as good quality source water for municipal treatment facilities. Hypoxic conditions occur when dissolved oxygen drops below 5.0 mg/L, resulting in stress on fish and other aquatic life. An anoxic condition occurs when dissolved oxygen drops below 1.0 mg/L, which can result in fish kills and the release of phosphorus, iron, manganese and other elements from the sediments. The release of these elements can result in increased algal blooms and treatment problems (undesirable tastes and odors) in the production of drinking water.

In July 2007, EPA approved the VADEQ's proposed dissolved oxygen standard (5.0 mg/L daily average, 4.0 mg/L minimum), which had been modified to account for naturally occurring decreases in dissolved oxygen due to thermal stratification in reservoirs. These new standards apply to the entire water column when the reservoir is well mixed and only to the surface waters (epilimnion) when the water column is vertically stratified. The most recent 2014 VADEQ's 303(d) listing of impaired water bodies lists the Swift Creek Reservoir as fully supporting in all categories: aquatic life, fish consumption, recreational contact and wildlife.

Thermal stratification is a natural process in many lakes and reservoirs that occurs when summer conditions warm the upper water column while the lower water column remains cooler. The warmer surface waters become lighter than the colder and denser bottom waters, resulting in layers of water separated by a zone of sharply changing temperature, known as a thermocline,

which inhibits vertical mixing. The thermal stratification continues until falling temperatures in the autumn cool the surface water sufficiently and disrupt the thermocline. Often a large fall storm event will result in rapid destratification of the lake.

During 2015, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in early May and lasting through mid-September. Thermal stratification of Swift Creek Reservoir was first observed on May 6, 2015 at both Station 5 and 8, corresponding with the first substantial drop in dissolved oxygen levels at and near the bottom. Stratification continued at both Station 5 and 8 until September 22, 2015, when the lake turned over and became thoroughly mixed. During the stratification period, dissolved oxygen concentrations within the epilimnion were above the VADEQ standard of 4.0 mg/L minimum for all stations. The time period and degree of thermal and dissolved oxygen stratification within Swift Creek Reservoir were consistent with past observations.

### **Secchi Depth, Total Suspended Solids, Turbidity, Total Nitrogen and *E. coli***

During the growing season of 2015, 70 secchi depth readings, total nitrogen and fecal coliform samples from the eight sites were collected and analyzed. Fifty-four (54) turbidity measurements and 68 total suspended solids samples were analyzed; turbidity was not sampled on April 2 and October 6 and total suspended solids were not sampled on October 21 from Station 5 and 8.

Secchi depth is a measurement of water transparency using a weighted black and white disk that is lowered into the water until the distinction between the black and white portions are no longer visible. The depth at which the distinction is no longer visible is then recorded as “Secchi disk transparency.” Secchi disk transparency is a function of the reflection of light from the surface off the disk. Secchi disk transparency is affected by the light absorption characteristics of the water as well as by dissolved and suspended particulate matter. It provides an estimate of water clarity and is closely related to turbidity.

All stations had median growing season Secchi disk readings ranging from 2.5 to 3.5 feet (Table 6); these results are similar to those observed in prior reports. The 2015 growing season median value for all sites (3.0 feet) was slightly greater than the median observed in 2014 (2.5 feet) with the increase in clarity likely correlated to the decreased algae density observed throughout the reservoir. Individual site growing season medians for turbidity ranged from 4.0 to 7.5 NTUs with the greatest turbidity observed in the shallow backwater stations. The growing season turbidity median (4.2 NTUs) was similar to that observed in 2014 (5.1 NTUs). The long-term consistency of both the Secchi disk depth and turbidity parameter measurements suggests good water clarity with minimal variability.



Table 6. Growing Season Median Values for Select Parameters (Surface) 2015.

STATION	SECCHI DEPTH (Feet)	TURBIDITY (NTUs)	TOTAL SUSPENDED SOLIDS (mg/L)	TOTAL NITROGEN (mg/L as N)	<i>E. coli</i> DENSITY (MPN/100 mL)
1	2.5	7.5	4.8	0.62	6.3
2	2.5	5.5	4.8	0.63	1.0
3	2.5	4.0	3.2	0.59	19.9
4	3.5	4.0	3.2	0.57	1.0
5	3.5	4.0	3.2	0.58	2.6
6	3.0	4.7	3.2	0.60	2.0
7	3.0	6.5	4.4	0.58	6.3
8	3.5	4.0	3.2	0.64	8.6
<b>Mainbody Stations (4, 5, 6, 8)</b>	<b>3.5</b>	<b>4.0</b>	<b>3.2</b>	<b>0.60</b>	<b>3.6</b>
<b>Shallow Stations (1, 2, 3, 7)</b>	<b>2.5</b>	<b>5.5</b>	<b>4.4</b>	<b>0.60</b>	<b>6.3</b>
<b>All Stations</b>	<b>3.0</b>	<b>4.2</b>	<b>3.4</b>	<b>0.60</b>	<b>4.1</b>

The 2015 growing season median total suspended solids concentration for all stations (3.4 mg/L) was similar to the concentration observed in 2014 (4.0 mg/L). The total suspended solids concentrations in the reservoir are consistently low, adding further support to the observed excellent water clarity condition. As in previous years, total nitrogen levels remained consistent throughout the reservoir with growing season median concentrations ranging from 0.57 to 0.64 mg/L as N (Table 6). The 2015 growing season median for all stations (0.60 mg/L as N) was similar to that observed in 2014 (0.64 mg/L as N) and indicated a nominal decrease in nitrogen enrichment throughout the reservoir. The mainbody stations' growing season medians were consistent with the shallow backwater stations.

*E. coli* densities as expressed as the Most Probable Number (MPN) of *E. coli* per 100mL ranged from a growing season median of 1.0 MPN/100mL at Station 2 to 19.9 MPN/100mL at Station 3. The growing season median for all stations in 2015 was 4.1 MPN/100mL. There was one individual value greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season observed at Station 4 on April 2 (387.3 MPN/100mL). During the non-growing season months, there were three (3) instances in the reservoir when *E. coli* densities were greater than the VADEQ maximum threshold (2.6% of total observations). In these occurrences, coliform densities ranged from 238.2 to 365.4 *E. coli* MPN/100mL. Each of the four (4) observations exceeding the state standard observed during the year occurred at a different station. The reservoir is populated by migratory and resident waterfowl and the isolated measurements of high *E. coli* densities are likely related to the sporadic movements and presence of the birds.

## **Temperature, pH, Conductivity, Lead and Zinc**

Water temperature in Swift Creek Reservoir varied normally according to season during 2015. Surface temperatures throughout the reservoir ranged from 4.2 to 31.2°C during the year with a median value of 17.7°C. No individual surface temperatures exceeded the VADEQ maximum standard of 32.0°C during 2015. Surface pH values ranged from 6.1 to 9.3 units with an annual in-lake median of 7.2 units, consistent with pH concentrations previously observed. On July 6, 2015 at Station 3 (9.3 units) and Station 8 (9.2 units) individual surface values fell outside of the 6.0 to 9.0 unit VADEQ acceptable range for pH. Conductivity measurements within the reservoir ranged from 46 to 274 µS/cm with an annual median of 83 µS/cm; an observation consistent with previously recorded values. Thirty-two lead and zinc samples each were collected and analyzed from the eight sites during the year. Lead concentrations ranged from below the reporting limit (<0.0025 mg/L) to 0.0030 mg/L with one measurable concentration noted, a decrease from the two measurable concentrations in 2014. All zinc concentrations were below the laboratory's detection limit (0.05 mg/L), a decrease from the four measurable concentrations noted during 2014.

## **Algal Community Structure of Swift Creek Reservoir**

A total of 43 individual genera of algae representing six phyla were documented in Swift Creek Reservoir during 2015. A lower median algal density per month was observed in 2015 (2884 cells/mL) as compared with 2014 (7516 cells/mL). Analysis of the general types of algae by phyla in Swift Creek Reservoir (Figure 4) indicated that the community structure continued to be comprised largely of golden algae/diatoms (Chrysophyta, 24.9%) and green algae (Chlorophyta, 31.7%). These two phyla combined represented 56.6% of the algal community observed; this was a decrease in dominance from the 87% composition observed in 2014. The frequency of occurrence for the taste and odor producing blue-green algae (Cyanoprokaryota, 28.3%) quadrupled as compared to 2014 (6.9%) and approximately double the quantity observed in 2013 (15.8%).

The ten most common algal genera were identified (Table 7). These ten genera combined represented approximately 74% of all algae observed in 2015. While some of these genera are potentially known to affect the taste and odor of the production water, there were no widespread taste and odor related problems resulting from algae in 2015.

Figure 4. A comparison of the frequency of occurrence of six algae phyla observed in Swift Creek Reservoir 2013 - 2015.

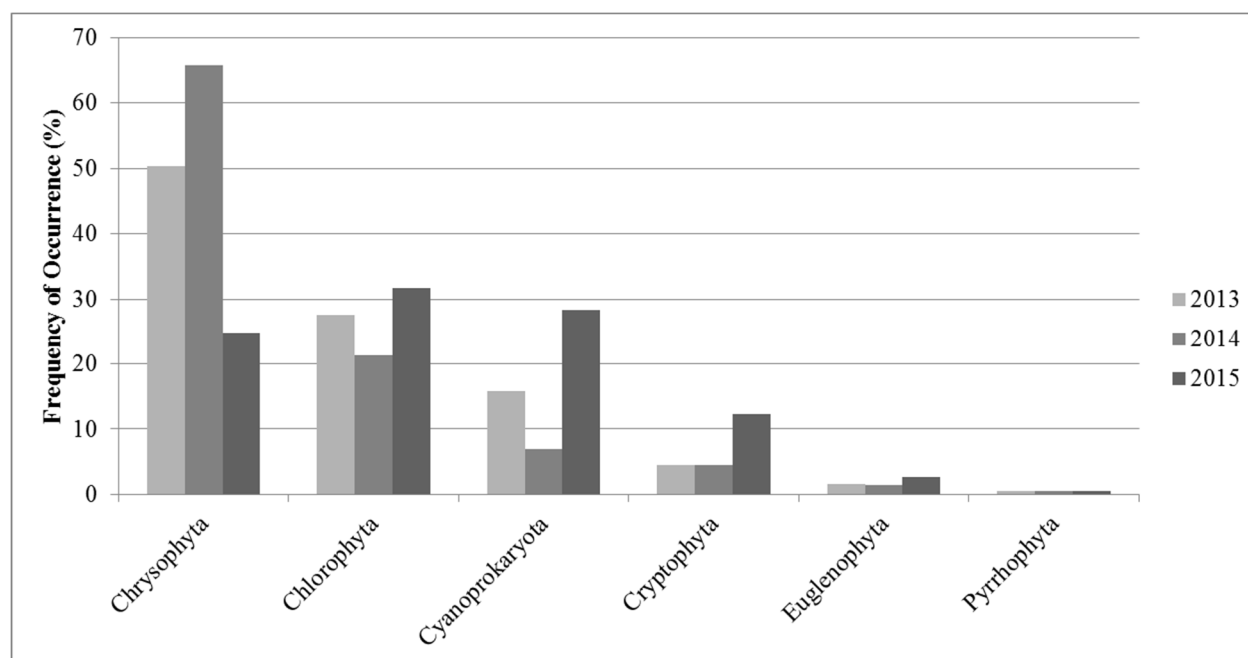


Table 7. Ten most common taxa of algae observed in Swift Creek Reservoir 2015.

Number	Phyla	Genus	% of Total Observed	Taste/Odor Produced
1	Chlorophyta	<i>Ankistrodesmus</i>	11.5	Grassy/Musty
2	Cyanoprokaryota	<i>Merismopedia</i>	11.1	Not Known
3	Cryptophyta	<i>Chroomonas</i>	9.7	Not Known
4	Cyanoprokaryota	<i>Aphanizomenon</i>	8.4	Rotten/Septic
5	Cyanoprokaryota	<i>Anabaena</i>	8.1	Rotten/Septic
6	Chrysophyta	<i>Melosira</i>	7.4	Musty
7	Chrysophyta	<i>Cyclotella</i>	6.7	Fishy
8	Chlorophyta	<i>Crucigenia</i>	4.1	Not Known
9	Chlorophyta	<i>Dictyosphaerium</i>	3.7	Fishy
10	Chlorophyta	<i>Scenedesmus</i>	3.6	Grassy

### Status of *Hydrilla* and its Control in the Swift Creek Reservoir

As discussed in the previous Swift Creek Reservoir Water Quality Data Reports, the rapid growing invasive aquatic weed, *Hydrilla verticillata*, was first identified in the Swift Creek Reservoir in August 2009. After studying the problem, action for the long-term management of *Hydrilla* was initiated by the introduction of triploid grass carp (*Ctenopharyngodon idella*) to the

reservoir in April 2010. An electrofishing survey conducted in September 2011 observed that the population was healthy and the fish were growing in size, which correlated with the observed reduction in the density and distribution of *Hydrilla* within the reservoir. Both 2011 summertime surveys indicated no visible areas of *Hydrilla* were present and this observation was confirmed again in the October survey. Surveys conducted during 2012 and again in 2013 confirmed the grass carp continued to be effective in controlling the growth of *Hydrilla*.

While the more vegetative structures of the *Hydrilla* plant had been minimalized in 2012 and 2013, in 2014 the *Hydrilla* biomass reestablished itself in the reservoir. Some reestablishment of *Hydrilla* was anticipated as a function of the plant's reproductive strategies such as root structures that produce tubers, which functionally prevent the complete removal of the plant from a water body and the aging grass carp population being unable to continue to consume the plant at the same rate as juveniles. In April of 2015, an additional 1,000 triploid grass carp were stocked into the reservoir to maintain the *Hydrilla* biomass at a manageable level.

## **Conclusions**

Indicators of water quality continue to suggest acceptable conditions in the Swift Creek Reservoir. A similar concentration of chlorophyll a was observed in 2015 as compared to the previous year indicating a consistent presence of algae in the reservoir. Throughout the reservoir, total phosphorus concentrations remained consistent with observations from previous years. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.028 mg/L as P and continues to be below the VADEQ nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for the surface water at all eight sites in Swift Creek Reservoir was 0.033 mg/L as P, below the county goal of 0.05 mg/L as P.

As in prior years, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in early May and lasting through mid-September. During this stratification period, dissolved oxygen concentrations within the epilimnion remained above the VADEQ standard of 4.0 mg/L for all stations.

Secchi disk readings ranged from 2.5 to 3.5 feet and were similar to those noted in prior reports. Individual site growing season medians for turbidity ranged from 4.0 to 7.5 NTUs with the greatest measurements observed in the shallow backwater stations. The growing season total nitrogen concentrations continued to be similar to those observed in past years with site medians ranging from 0.57 to 0.64 mg/L as N and indicated a nominal decrease in nitrogen enrichment.

There was one observation of individual *E. coli* density values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season. Water temperature in Swift Creek Reservoir varied normally throughout the year. Surface pH values ranged from 6.1 to 9.3 units. On July 6, 2015 at Station 3 (9.3 units) and Station 8 (9.2 units) individual surface values fell outside of the 6.0 to 9.0 unit VADEQ acceptable range for pH. Conductivity values within the reservoir were acceptable with an annual median of 83  $\mu\text{S}/\text{cm}$ . Lead concentrations ranged from below the reporting limit ( $<0.0025$  mg/L) to 0.0030 mg/L with one measurable concentration recorded during 2015. All zinc concentrations were below the laboratory's detection limit (0.05 mg/L), a decrease from the four measurable concentrations noted during 2014.

A total of 43 individual genera of algae representing six distinct phyla were documented in Swift Creek Reservoir during 2015 and analysis of the general types of algae indicated that the community structure continued to be dominated by golden algae/diatoms and green algae. There were no indications of algae related taste and odor problems reported in 2015. The more vegetative structures of the *Hydrilla* plant had been minimal in 2012 and 2013. In 2014, the *Hydrilla* biomass reestablished itself in the reservoir. Some reestablishment of *Hydrilla* was anticipated as a function of the plant's reproductive strategies preventing the complete removal of the plant from a water body. In April of 2015, an additional 1,000 triploid grass carp were stocked into the reservoir to maintain the *Hydrilla* biomass at a manageable level.